AD-A065 157 CALIFORNIA UNIV BERKELEY ELECTRONICS RESEARCH LAB F/G 20/9

PLASMA THEORY AND SIMULATION.(U)

SEP 78 C K BIRDSALL, W FAWLEY, Y J CHEN N00014-77-C-0578

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THIRD QUARTER PROGRESS REPORT

on

PLASMA THEORY and SIMULATION

July 1 —— September 30, 1978

Research during the third quarter of 1978 is reported here.

Our research group uses both theory and simulation as tools in order to increase the understanding of instabilities, heating, transport, and other phenomena in plasmas. We also work on the improvement of simulation, both theoretically and practically.

Our staff is —

Professor C. K. Birdsall (*Principal Investigator*)	191	M	Cory Hall (642-4015)
Dr. William Fawley (*Post Doctorate*)	119	ME	Cory Hall (642-3477)
Yu Jiuan Chen, Douglas Harned, Jae Koo Lee, Lee Buchanan (*Research Assistants*)	119	MD	Cory Hall (642-1297)
Stephen Au-Yeung (*Programmer*)	119	MD	Cory Hall (642-1297)
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October 1, 1978

ERDA Contract EY-76-S-03-0034 (Project Agreement No. 128)
ONR Contract N00014-44-C-0578

ELECTRONICS RESEARCH LABORATORY

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Section I

PLASMA THEORY

A. DRIFT CYCLOTRON INSTABILITY

J. K. Lee

No additions to theory this quarter.

B. PLASMAS WITH FIELD REVERSAL

Douglas Harned (*Prof. C. K. Birdsall*)

A simplified model is being examined to analyze the stability of the $m = 0$ mode in long-layer field reversed plasmas. The instability is characterized by a high energy ion beam propagating through a relatively cold background plasma. It is of interest to see if this instability, which is observed in simulation plasmas, is real or numerical in nature.

Using the infinite radius limit with a long layer, the layer may be unwrapped into a slab (see Fig. 1). In the slab model, the $m = 0$ mode corresponds to rigid motion of the slab beam toward one wall. Our model has been considered by Friedman,[1] which consists of a six-cell beam-plasma system. The beam propagates uniformly through a region one cell in width, straddling the centerline of the plasma. (In the six-cell model this corresponds to the line separating the third and fourth cells.) The walls are treated as perfect conductors. The only zero-order magnetic field is assumed to be the self-field (B_z^0) of the zero-order beam current (J_y^o). Quasineutrality, $n_e = n_i + n_b$

[1]A. Friedman, Cornell University, private communication.

(n_e, n_i, and n_b are the electron, ion and beam densities, respectively), is assumed. The displacement current is neglected as we are looking only at low frequency phenomena. The electrons are taken as a perfectly conducting fluid. The finite-differenced, linearized equations of motion for both the beam and the plasma are used to obtain a quadratic equation for the frequency $\omega + i\gamma$. There are two possible modes, symmetric and anti-symmetric with respect to the perturbed electric field. When the roots are found, using the root-solver ZANALYT, the symmetric mode appears stable while the antisymmetric mode has positive growth rates for certain values of the beam velocity and density. The most unstable regime is for beams having densities larger than the plasma density and velocities large relative to the Alfven velocity. Another weaker area of instability was found for low density, low velocity beams.

In order to prevent problems that might be a result of the small number of cells used by Friedman in the six-cell case, we have expanded the model by constructing an algorithm for an arbitrary number of cells. However, the width of the beam was retained at one cell. A polynomial of order $N = I/2 - 1$ was obtained, where I is the number of cells. This polynomial was then solved numerically, again using ZANALYT. The results for cases from 8 to 20 cells confirmed the results of the six-cell model. The growth rates were comparable (on the order of the ion-cyclotron frequency) and instability was observed in the same regions of parameter space (the parameters being beam velocity and density).

The multicell model still contains the weakness of having only a one-cell wide beam. This problem has caused us to seek an analytic solution; this work is not yet complete. The model is essentially the same as that described above. The linearized equations of motion are used for the beam

$$\ddot{x}^{1} = \frac{e}{m}\left[E_x^1 + v_y^o\frac{B_z^1}{c} + v_y^1\frac{B_z^o}{c}\right] \tag{1}$$

$$\ddot{y}^{1} = \frac{e}{m}\left[E_y' - v_x'\frac{B_z^o}{c}\right]. \tag{2}$$

An important point here is that in the models using a one-cell beam the $v_y'(B_z^o/c)$ and $v_x'(B_z^o/c)$ terms do not appear because the antisymmetry of B_z^o made these terms vahish upon cell averaging. The electrons are still considered as a perfectly conducting fluid,

$$E' + v_e' \times \frac{B^o}{c} = 0 ;$$

quasineutrality is again assumed. When these relations are combined with Maxwell's equations, second order differential equations are obtained for each region in the model for the perturbed y directed electric field E_y'. These equations can, in principal, then be solved by using boundary conditions at the perturbed boundary. This solution is not yet complete.

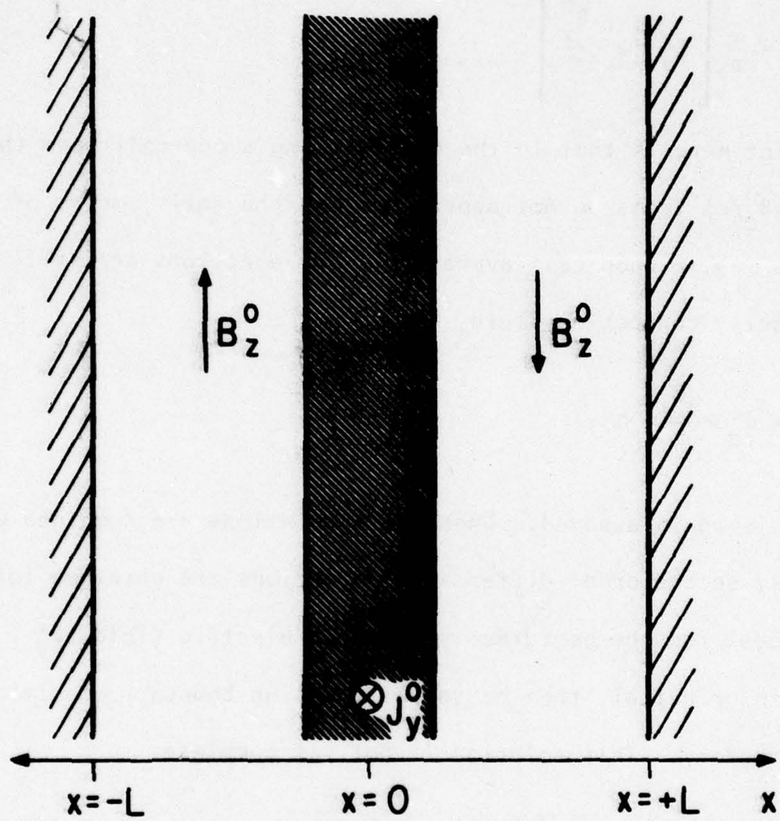

FIG. 1 SLAB MODEL. The slab beam (shaded region) propagates in the y-direction, through a plasma bounded by conducting walls at $x = \pm L$. The $m = 0$ mode corresponds to a rigid displacement of the slab beam in the x direction.

Section II
SIMULATION

A. QUASILINEAR SIMULATION OF A MIRROR MACHINE

Dr. Y. Matsuda with Dr. H. L. Berk (LLL)

This project is in limbo; there will be no further report.

B. ONE DIMENSIONAL ES1 CODE FOR SHEATHS

Y-J Chen (*Prof. C. K. Birdsall*)

No special work to report this quarter.

C. PARTICLE TRAJECTORIES IN A CUSP FIELD

Y-J Chen (*Prof. C. K. Birdsall*)

No special work to report this quarter.

D. SIMULATIONS OF DRIFT-CYCLOTRON INSTABILITY

J. K. Lee (*Prof. C. K. Birdsall*)

We have made several simulations of the drift-cyclotron instability using EZOHAR. These results are preliminary; only a general description will be presented in the following.

Our simulations include exact particle dynamics of both electrons and ions (i.e., the guiding center approximation of the electrons was not used)

with flute-like ($k_\parallel = 0$) two-dimensional electrostatic perturbations. Typical parameters are

number of spatial grids = 32 × 32

number of particles (electrons or ions) = 16×16×16 to 32×32×32

$\omega_{pe}/\omega_{ci} = \omega_{ce}/\omega_{ci} = (\omega_{pi}/\omega_{ci})^2 = m_i/m_e = 25,\ 11,\ 9$ (three cases so far)

$\omega_{pe}\Delta t \lesssim 0.5$

$\rho_i/L_n = \frac{1}{2} \sim 1$

where the above symbols are defined in the last QPR (p. 2).

Simulations show several modes growing exponentially in time up to $\omega_{ci}t \sim 10$. The comparison of this linear behavior with the existing linear theories is not complete at this moment, since most of linear theories use the local approximation where $\rho_i/L_n \ll 1$. The only nonlocal theory (known to us) is that of ROOTS[1], which has a sinusoidal guiding center density profile like our model, but which is periodic in ∇n direction, where our model is unbounded in that direction. The linear growth rates and frequencies in the simulations are found to agree better with the nonlocal theory predictions rather than with those of the local theory.

At saturation, the total electrostatic field energy reaches about 2% of the initial ion kinetic energy for the above mass ratios. These simulation saturation levels are now being compared with a small number of existing nonlinear theories, and the preliminary results show quite good comparison. At and after saturation, the phase space plots ($v_y - y$) of electrons and ions form vortex-like structures in accordance with the most unstable mode and the density profiles of both species start to develop a stretching pattern (both of these are similarly observed in the lower-hybrid-drift instability simulation[2]). The density gradient stretching was especially clearly seen in movies; these have the potential contour plot at the top of the frame and the density profiles of electrons and ions superimposed in different colors at the bottom. The movies also show clearly the mode localization in x (or y) and the mode propagation in the x-y plane (mostly in the ion diamagnetic drift wave direction).

[1] M. J. Gerver, "ROOTS, A Dispersion Equation Solver", UCB/ERL Memorandum No. M77/27 (Oct. 31, 1976).

[2] D. Winske and P. C. Liewer, "Particle Simulation Studies of the Lower Hybrid Drift Instability", Phys. Fluids 21, pp. 1017-1075 (1978).

Section III

CODE DEVELOPMENT AND MAINTENANCE

A. ES1 CODE: MODIFICATION OF ES1 TO USE POST-PROCESSOR ZED

Dr. W. M. Fawley

ZED is a post-processor routine that allows the user to manipulate and plot time histories of variables and mode amplitudes contained in the output produced by the plasma simulation code EZOHAR. The manipulations, such as Fourier transforming in time and cross-correlation, can be extremely useful in determining certain properties, e.g. mode exponential growth rates. ZED has proved so beneficial in use with EZOHAR that we decided to modify the simpler codes ES1 and EM1 to produce ZED-readable output.

ZED expects both a "STATE" file and "HISTORY" file to exist on disk when it is run. The STATE file tells ZED the last time step (IT) completed (actually the last time step divisible by 50), the value (DT) of the time step, and how often (in time steps) each variable is stored (ISMODE, normally 1; i.e., each variable is stored each time step). ZED will normally ask the user for his/her box number and file identification.

The HISTORY file contains the actual time histories. The file is split into two parts. The first part contains the time histories of variables such as the electrostatic, kinetic, and total energy while the second part contains time histories of mode amplitudes and variable values at particular grid points. The user has no choice as to what variables are stored in the first part, but does instruct the code via input parameters as to which modes are to be stored in the second part. The HISTORY file replaces the

functions performed by the subroutine HISTRY in ES1 and EM1. However, "snapshots" of the potential and other variables are still written in DD80 files. Thus, the user will use TEKPLOT to see the snapshots produced at a particular time during the simulation run.

Most changes made to ES1 and EM1 were required to write the STATE and HISTORY files. The new, modified codes are called "ESZ" and "EMZ". Their respective source listings, "SESZ" and "SEMZ" are global files contained in user number 1221, directory .ZOH . Both codes must be compiled with CHATR, and the binary routine "BEM1" (contained in EM1LIB) must be present. The user must also specify TV80LIB, ORDERLIB, and CF76LIB (this order is crucial for EMZ).

In general, it has proved very efficient (in CPU time) to use binary libraries when debugging and modifying (by a factor of 3 - 5) these codes. Please see the July 1, 1977 QPR, pp. 55-57, for information on maintaining binary libraries and loading procedures (using LOD). For convenience the binary libraries BESZLIB and BEMZLIB are also present in directory .ZOH , user number 1221. Such library contains BEM1 in addition to the ESZ and EMZ binary routines. The source libraries SESZLIB and SEMZLIB also exist in directory .ZOH . It is strongly suggested that each time a user creates a new run file ESZ or EMZ, a symbol table also be created. This allows one to debug the programs dynamically with the system routine DBCTRL.

For users who are interested in modifying their own versions of ES1 and EM1 to produce ZED-compatible output, SESZ and SEMZ are written in a way to point out the necessary deletions and additions. First of all, the new subroutines MDSET, TSET, and WRTSTATE are needed to control IO to the STATE and HISTORY files. TSET establishes the HISTORY file and writes (through

"TSAVE" and RSAVE) values of variables such as total energy into the first part of the HISTORY file. MDSET reads inputs as to which modes are stored (more on this later) and writes (via MWSAVE and MRSAVE) the second part of the time history file. WRTSTATE creates a new STATE file (and destroys the old STATE file) each time it is called. At the end of a run, it closes the HISTORY file. ESZ and EMZ have different versions for each of the programs.

The user also should eliminate the routine HISTORY and PLTHST as these are no longer needed. Elsewhere through the routines common to ES1 and ESZ and EM1 and EMZ, deletions and additions are flagged with comment statements in the following ways:

All lines to be deleted have "CK" in columns 1 and 2. Each line (or group of lines) is preceded by a line with "CADD" in columns 1 - 4; the line will tell you the number of lines to be added to your code. In general, this method has worked well (one success out of one try). If your version of ES1 uses the PUTT compiler, you must change all format statements with "*" delimited output statements, to be quote (") delimited statements, in order to be compatible with the CHATR compiler.

INPUT changes: The routine MDSET requests via the INPUT file information on which modes to store. This information should go after the "namelist" input, separated by a "STOP" statement (this STOP replaces the SEND in PUTT- compiled ES1 INPUT files). The modes histories requests should be in right-adjusted (O5, I5) format. A blank line ceases the requests. The O5 input is bbbTV where T specifies the type of information, i.e., value at a particular grid point, and V specifies the actual variable stored (i.e., electric potential).

	T = 0	mode energy	
	1	complex mode amplitude (2 words stored)	
	2	value at a particular grid point	
	V = 1	electric potential (or longitudinal electrostatic energy if T = 0)	
	2	not used	
	3	current density in y-direction (EMZ only)	
	4	total charge density	
	5	electric field in x direction	
EMZ	6	electric field in y direction	T = 2
only	7	magnetic field in z direction	T = 2
EMZ	6	wave amplitude F^+ polarization	T = 1
only	7	wave amplitude F^- polarization	T = 1

The I5 input specifies each the grid point position (T = 2) or the mode number (T = 0 or T = 1).

After the blank line which closes the mode history input goes the species 1 and 2 input for the routine INIT. No "STOP" is needed after the mode history blank line. Sample input files for ESZ and EMZ are in SESZLIB and SEMZLIB under the name INPUT. The main source routines in the two libraries are called MAINESZ and MAINEMZ, respectively.

Use with ZED.

A user may use ZED on the HISTORY and STATE files as soon as the latter is first written (after the 50^{th} time step). If one is familiar with use of ZED with ZOHAR output, there should be no difficulties. "ZED REPORT", which summarizes the available commands, may be obtained from

```
FILEM RDS 1234 ZEDREP(LF)END / T V
TRIX AC / T V
PRINT(<NIP ZEDREP BOX NNN ZEDREPORT>)
END
```

Until the "MODES" command is given, the user may access time histories of momenta (PX1,2; PY1,2), kinetic energies (KE1,2), electrostatic energy (ESE), and total energy (TE) in ESZ output. For EMZ output, the equivalent variables are PX1,2; PY1,2; KE1,2; TE; EXE (longitudinal electrostatic energy); EYE (electric field energy in y direction); BZE (magnetic field energy in z direction; EYLE, EYRE (wave energy in left and right polarizations); and TEMP1, IONTMP (average electron and ion temperatures in electron volts).

After the user specifies "MODES" to ZED, times histories of the mode energies and amplitudes may be accessed. To do this, the user specifies the same code for a given mode (e.g. READ 01 01 00), EXCEPT he'she MUST include "oo" after the mode or grid point number. ZED expects a 2½d output and thus KY or NY (which is 00 in 1½d output) must be specified. In addition, to read a complex amplitude (e.g. PHI(KX)), an ampersand must be included after the "00". This instructs ZED to read the second (imaginary) word of the complex amplitude.

RELIABILITY: ESZ has been tested on a several sample problems and appears to work well. No physics was changed in this code relative to ES1, so the two codes should give identical answers on a particular problem. EMZ, however, has been not tested at all and a CAVEAT EMPTOR must be extended. In addition, a (hopefully) faster and better routine was put in the routine "ACCEL" to compute electron temperatures. The changes may have bugs. Thus, any user who is so interested is encouraged to test EMZ extensively.

Good luck.

B. EMI CODE

Nothing special to report this quarter.

C. EZOHAR DEVELOPMENT

J. K. Lee

Code is running.

D. ESI + EFL CODE

J. K. Lee (*Prof. C. K. Birdsall*)

A report on this code may be prepared for the Journal of Computational Physics. We may add work on the Lagrangian fluid version.

E. 1½D PARTICLE-FLUID HYBRID FOR LOWER HYBRID DRIFT WAVE INSTABILITY

Y-J Chen (*Prof. C. K. Birdsall*)

A 1½d hybrid model for the lower-hybrid-drift instability has b-en studied. Using the "ghost" ion method reported by B. I. Cohen and G. R. Smith,[1] ions in the simulation are distributed in v_x, v_y and y explicitly. Each ion represents many ghost ions moving along identical trajectories except for time-independent displacements in x. The initial ghost ion position x_o is calculated as it is at the $x=0$ plane at the present

Bruce I. Cohen and Gary R. Smith, "Efficient Method for Local Simulation of Drift Wave Instabilities", Proc. 8th Conf. on Numerical Simulation of Plasmas, Monterey CA, June 28-30, 1978.

time t. Then the charge q and mass m of this ghost ion are modified by a weighting function $W(x_o) = n(x_o)/n_o$. If the wave perturbation is localized at the $x = 0$ plane, i.e.,

$$k_y^2 \gg k_x^2 \gg L^{-2} , \tag{1}$$

where L is the density scale length, the local approximation in the density gradient direction is used and $W(x_o)$ can be expressed as

$$W(x_o) = \begin{cases} 1 - \dfrac{x_o}{L} & , \quad x_o < L \\ 0 & , \quad x_o \geq L . \end{cases} \tag{2}$$

Since the instability is characterized by

$$\omega_{ci} \ll \omega \ll \omega_{ce} , \tag{3}$$

$$\left. \begin{aligned} & a_i^{-2} \ll k_\perp^2 \ll a_e^{-2} , \\ & a_e^2 \ll L^2 , \end{aligned} \right\} \tag{4}$$

the ions are treated as unmagnetized particles. The x displacement of ions is

$$x(t) = x_o + v_x(t{=}0)t - \frac{1}{2} \frac{e}{m_i} E_{x_o} t^2 . \tag{5}$$

If the ion is at the $x = 0$ plane at time t, we get

$$W(x_o) = L - \left(\frac{1}{2}\frac{e}{m_i}\, E_{x_o} t^2 - v_x(t=o)t\right)\Big/ L \qquad (6)$$

where $\left[\frac{1}{2}\frac{e}{m_i} E_{x_o} t^2 - v_x(t=0)t\right]$ has to be much less than the ion Larmor radius, a_i , in order to satisfy the unmagnetized condition.

Under inequalities (3,4), the electrons may considered as a linearized magnetized fluid with a drift velocity v_o ,

$$v_o = v_E + v_{de} = v_E + \frac{T_e}{m_e \omega_{c_e}} L^{-1} \qquad (7)$$

in the y direction, where v_E is the $E \times B$ drift. Since the electron Larmor radius a_e is much less than the scale length L , the electron charge, mass and density distribution in x , i.e., $\rho(x)$, is constant during the simulation. There are two ways to treat this magnetized electron fluid. One way is to simulate the 1½d electron fluid directly. After linearization, the continuity equation can be written as

$$\frac{\partial \rho_1}{\partial t} + v_o \frac{\partial \rho_1}{\partial y} = -\frac{d\rho_o}{dx} v_{1x} \quad \rho_o\left(\cancel{\frac{\partial v_{1x}}{\partial x}} + \frac{\partial v_{1y}}{\partial y}\right) \qquad (8)$$

and the momentum equations are reduced to

$$\frac{\partial v_{1x}}{\partial t} + v_o \frac{\partial v_{1x}}{\partial y} = \frac{q}{m} v_{1y} B_o + \frac{\gamma v_t^2}{\rho_o} \frac{\partial \rho_1}{\partial x} \qquad (9)$$

and

$$\frac{\partial v_{1y}}{\partial t} + v_o \frac{\partial v_{1y}}{\partial y} = \frac{q}{m}\left(E_y - v_{1x} B_o\right) - \frac{\gamma v_t^2}{\rho_o} \frac{\partial \rho_1}{\partial y} \ . \qquad (10)$$

These three equations can be solved by a predictor-corrector scheme which takes care of the convective terms $v_o(\partial/\partial y)$ in them. For example, Eq. (8) becomes

$$\frac{\rho_j^{n,p} - \rho_j^{n-1}}{\Delta t} + v_o \frac{\rho_{j+1}^{n-1} - \rho_{j-1}^{n-1}}{2\Delta y} = - \frac{d\rho_o}{dx} \frac{v_{x_{j+\frac{1}{2}}}^{n-\frac{1}{2}} + v_{x_{j-\frac{1}{2}}}^{n-\frac{1}{2}}}{2} - \rho_o \frac{v_{y_{j+\frac{1}{2}}}^{n-\frac{1}{2}} - v_{y_{j-\frac{1}{2}}}^{n-\frac{1}{2}}}{\Delta y} \qquad (11)$$

and

$$\frac{\rho_j^{n} - \rho_j^{n-1}}{\Delta t} + v_o \frac{\rho_{j+1}^{n,p} - \rho_{j}^{n,p}}{2\Delta y} = - \frac{d\rho_o}{dx} \frac{v_{x_{j+\frac{1}{2}}}^{n-\frac{1}{2}} + v_{x_{j-\frac{1}{2}}}^{n-\frac{1}{2}}}{2} - \rho_o \frac{v_{y_{j+\frac{1}{2}}}^{n-\frac{1}{2}} - v_{y_{j-\frac{1}{2}}}^{n-\frac{1}{2}}}{\Delta y} \qquad (12)$$

where ρ_j^n in Eq. (12) is the final solution. Unfortunately, this method might take a relatively long time to run on the computer.

The second way is to bring in the electron effects through Poisson's equation, with the electron susceptibility $\chi_e^{(1)}$ which can include all the nonuniformity information. This will be presented later.

F. RJET (MINI-USERS' CENTER) DEVELOPMENT

S. Au-Yeung (Prof. C. K. Birdsall)

Our RJET to the MFENCC (Livermore) consists of (see Fig. 1) one PDP 11/04 computer that contains

1	KD11-D	Processor module (CPU)
1	KY11-LA	Operator's console
1	M9301-YB	Bootstrap/Terminator module
1	MS11-JP	MOS memory
1	DD11-DK	Expander backplane
1	BA11-KK	Mounting box
1	M7850	Parity controller
1	DL11-WA	Serial line interface and Real-time clock
2	DMC11-AR	DDCMP Microprocessor module
2	DMC11-DA	Line unit module
1-2	DZ-11-A	Asynchronous multiplexer (8 asynchronous serial lines/unit)
1	BM873-YC	Restant loader containing ROM with bootstrap program

1 Dataphone 4800 baud

1 Channel Interface

upto 16 EIA standard RS232C interface terminals

1 Terminal used as the console.

The log in procedure is:

(1) Turn on the terminal

(2) Type in

a(or c for CRAY)_user #_suffix_acct #_(ctrl-z) password

Although the default baud rate is 300, it can set up to 9600 by:

(1) Setting the switch to the desired baud rate

(2) Repeat the break key until an asterisk (*) comes up; then use any keyboard key once.

When the baud rate is changed successfully, the message "SPEED CHANGE COMPLETE" should appear.

The software handles outputs for several different kinds of terminals. Keying in one of the following parameters after typing CTRL-B tells what type of terminal is used:

parameter	type of terminal	
a	MINI (not available)	
b	TT33	
c	TI SILENT 700 (DEFAULT)	
d	DMEL	DATA MEDIA
e	ADM	LEAR SIEGLER
f	HP45	HEWLETT-PACKARD
g	TEC	TEC INC.
h	TEK	TEKTRONIX
i	ANN	ANN ARBOR

For example, by typing (ctrl-b)e, the message @ADM will appear on the screen; then, whenever the output of a program exceeds 24 lines, it will stop, ring the bell, and wait until receiving ctrl-y to continue.

To users planning on duplication of our RJET, please take note of the following concerning the hardware and software of this network:

(1) The PDP 11/04 is physically noisy with two whining blowers; therefore, the location must be taken into consideration.

(2) The 2400 baud rate is recommended when running TEKPLOT on a Tektronix terminal. If 4800 baud rate is used, set CPS to 960 before doing any plotting.

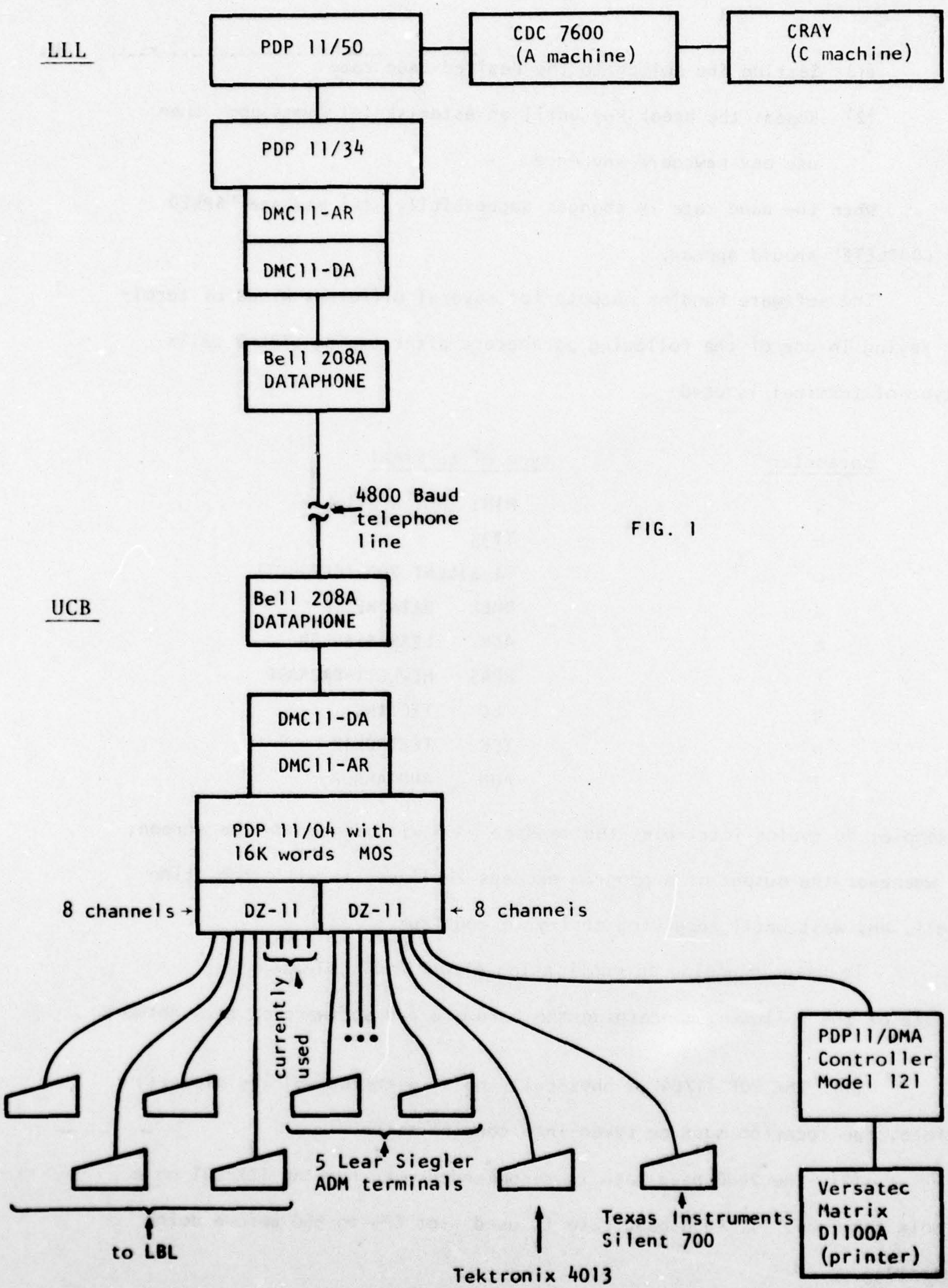
LLL
PDP 11/50
CDC 7600
(A machine)
CRAY
(C machine)
PDP 11/34
DMC11-AR
DMC11-DA
Bell 208A
DATAPHONE
4800 Baud
telephone
line
UCB
Bell 208A
DATAPHONE
DMC11-DA
DMC11-AR
PDP 11/04 with
16K words MOS
8 channels
DZ-11
DZ-11
8 channels
currently
used
PDP11/DMA
Controller
Model 121
5 Lear Siegler
ADM terminals
to LBL
Tektronix 4013
Texas Instruments
Silent 700
Versatec
Matrix
D1100A
(printer)

FIG. 1

Section IV

PLASMA SIMULATION TEXT

Chapters 1 - 7 of Part I, Primer and Chapters 8 - 10 of Part II, Theory have been revised. Copies of these will be made to fill requests and for use in courses (e.g. here and at Stanford).

Section V

SUMMARY OF REPORTS, TALKS, PUBLICATIONS IN PAST QUARTER

None this quarter.

VISITOR: Dr. Liu Chen from PPPL visited with us during May, completing:

(a) "Theory of Short Wavelength Drift Tearing Instabilities" (with P. H. Rutherford)

(b) "Effects of Curvature on Drift Tearing Modes" (with H. L. Berk).

ERRATA

The code ROOTS[1] was noted to work incorrectly for ring distributions with the local approximation. M. J. Gerver has found an error which, when removed, Y. Matsuda found gave the same results as the code by N. Lindgren. Change

```
001879   SUM2 = SUM2*(1. + OMEGA*EPSI/KYAI)
```

to

```
001879   SUM2 = SUM2*(KYAI + OMEGA*EPSI)
```

[1] M. H. Gerver et al., "Normal Modes of a Loss Cone Plasma Slab with Steep Density Gradient", Memo. No. ERL-M602, 24 Sept. 1976, Appendix I.

DISTRIBUTION LIST

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Donald Priester
Walter Sadowsky
Oscar Manley

Contractor (ONR)
Padgett (plus 67 to ONR list)

Berkeley Campus
Birdsall, Chen, Harned, Buchanan, Lee, Lichtenberg, Lieberman, Arons, McKee, Chorin, Au-Yeung

Berkeley Lab (LBL)
Kunkel, Kaufman, Cooper, Maria Feder (library), Pyle, Berk

Livermore (LLL)
Byers, McNamara, Maron, Kruer, Langdon, Lasinski, Max, Fuss, Bruijnes, Tull
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Briggs, Lee, Chambers, Smith, Matsuda

Israel
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Dawson, Lin

Stanford
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Columbia Univ.
Chu

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Oak Ridge NL
Meier, Dory, Mook (Library)

Los Alamos SL
Lindman, Nielson, Burnett (Library)
Gitomer, Lewis, Hewett, Forslund, Godfrey

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Pettus

Northwestern Univ.
Denavit

Naval Research Lab
Boris, Winsor, Lee

SAI
Klein, McBride, Wagner

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